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Poultry Housing Tips

Without Air Movement Evaporative Cooling Pads Can Increase Bird Heat Stress

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Though evaporative cooling is used around the world to keep birds cool during hot weather, by itself it is not a very effective method of reducing bird heat stress. To understand why, one must understand how a bird cools itself.

Figure 1. Thermal image of rooster in 77°F room.

Poultry feed is rich in energy/calories (similar in energy density to chocolate cake with frosting). The energy in the feed is used by the birds to grow, produce eggs, move, as well as, power the basic functions of life (breathing, pumping blood, maintaining body temperature, immunity, etc.). Though we view birds as very efficient animals, the fact is that only 25% of the energy in the feed consumed is actually used for these functions, the remaining 75% is essentially put off in the form of heat – heat a bird must rid itself of in order to maintain normal body temperature and survive.

In a way, a bird is not that different from an automobile. A gallon of gas is packed full of energy. The car's engine "consumes" the gasoline and uses the energy from the fuel for motion, power the air conditioning system, lights, radio, as well as power basic functions (pulling air into the engine, pumping gasoline, maintaining proper engine temperature, etc.). Like a bird only, a small percentage of the energy in the fuel is used for these purposes (approximately 35%), the remainder is put off in the form of excess heat. If the engine does not rid itself of this heat (primarily though the use of its radiator and tail pipe), the engine temperature can increase to a point where the engine will seize up and "die".

A bird rids itself of excess heat primarily in two ways: (1) it loses heat to the air around it (sensible heat loss) and (2) it loses heat through the evaporation of water off of its respiratory system (latent heat loss). Sensible heat loss is fairly simple to understand. The bird's body is warmer than the air and therefore the bird loses heat to the air surrounding it. The cooler the

air the greater the amount of heat loss. The warmer the air, the smaller the amount of heat loss. Latent, or evaporative heat loss can be a harder concept to understand. As a bird breathes, moisture evaporates from the respiratory system. As this moisture evaporates, heat is removed from the bird much as the evaporative cooling pads "remove" heat from air entering a house during hot weather. As you might expect, the amount of heat a bird loses through the evaporation of moisture off of its respiratory system depends on the relative humidity of the air it breathes. The lower the relative humidity, the more moisture the bird can evaporate off of its respiratory system the more heat which is removed from the body. Conversely, the higher the humidity the lower the amount of moisture evaporated from its respiratory system the lower the amount of heat removed. From the day a bird is hatched, it continually utilizes both these methods of heat removal to maintain an ideal body temperature.

How much heat are we talking about? At 70°F, a five pound broiler produces approximately 60 Btu's of heat each hour, which is roughly equivalent to the amount of heat produced by a 25 watt incandescent light bulb. At a relative humidity of 50%, approximately 36 Btu's/hr of heat (60%) is lost from a bird through the evaporation of moisture off its respiratory system and 24 Btu's/hr (40%) is lost to the air surrounding a bird. How does this compare to you and me? Seated and at rest the average male adult will produce approximately 340 Btu's of heat each hour (1/7 of the heat produced by a broiler on a per pound basis). Only 28% of our heat loss is due to the evaporation of moisture from our respiratory system and skin (perspiration). 72% of our heat loss is lost to the air surrounding us. We are far less dependent upon the cooling produced by the evaporation of moisture to maintain our body temperature than are birds. As a result we are much less sensitive to high humidity situations than are the birds we grow.

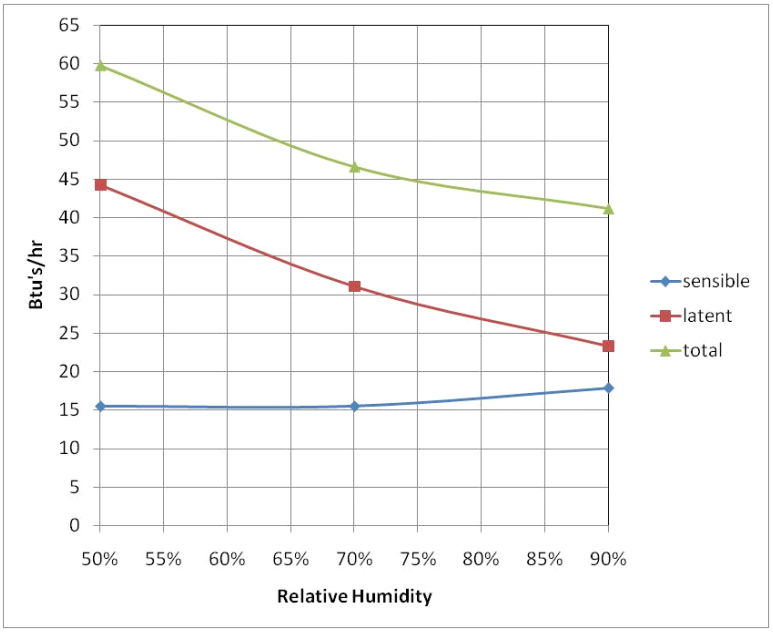

Figure 2. Heat loss from a five-pound-broiler at 77°F (from Genc and Portier)

Figure 2 illustrates how much a bird's ability to rid itself of excess heat is affected by relative humidity (Genc and Portier, 2003). At an air temperature of 77°F, total heat loss from a five pound broiler decreases from 60 Btu's/hr to approximately 40 Btu's/hr as relative humidity increases from 50% to 90%. This means that as relative humidity increases, a bird's body temperature will rise, and as a result, the bird will reduce its consumption of feed to reduce the amount of heat it is producing.

It is important to note that though at an air temperature of 70°F (50% Rh) approximately 60% of a bird's heat loss is through evaporation; at 77°F (50% Rh), 75% of a birds heat loss is through evaporation. This increase in evaporative heat loss is a result of the fact that the higher the air temperature, the lower the amount of heat the bird will lose to the air surrounding it, and the more it has to rely on the evaporation of moisture from its respiratory system to remove excess heat from its body. A bird can increase evaporative heat loss through the act of panting (increasing the amount of air moving over its respiratory system). But, the problem is that as the relative humidity of the air increases, panting becomes less effective, which results in an overall decrease in heat loss from a bird. The decrease in heat loss will result in an increase in body temperature which in turn will lead to a reduction in feed consumption in an effort to generate less heat. The increase in panting diverts energy from growth and the reduction in feed consumption results in reduction in feed conversion efficiency and weight gains.

A temperature of 77°F is not what most people would view as a "stressful" temperature, but in fact for a bird it can very well be demanding if the relative humidity is high. As illustrated in Figure 2, the total heat loss from a five-pound-bird decreases approximately 25% as humidity increases from 50 to 70%. If the relative humidity increases to 90%, the heat loss from a bird is decreased by nearly 35%. A reduction in heat loss from a bird of this magnitude will result in significantly increased body temperature and substantially reduce bird performance.

What happens to birds at higher air temperatures? At 86°F and a relative humidity of 50%, total heat loss from a five-pound-bird drops to approximately 45 Btu's/hr (a decrease of 25% from 77°F, 50% Rh). Now, nearly 80% of the birds heat loss is through respiration! This means that the relative humidity of the air in a house has an even greater effect on the bird's ability to maintain a proper body temperature. If the relative humidity of the air in a house were to increase to 90%, total heat loss from a bird would be reduced by 70% because heat loss through respiration drops to essentially zero. In short, the research has shown that between a relative humidity of 70% and 90% (at an air temperature of 86°F), respiratory heat loss for a five-pound-bird goes from approximately 35 Btu's/hr to essentially zero. Since the amount of heat loss from the surfaces of the bird to the air is minimal (approximately 13 Btu's/hr) a bird will not be able to survive (Figure 3).

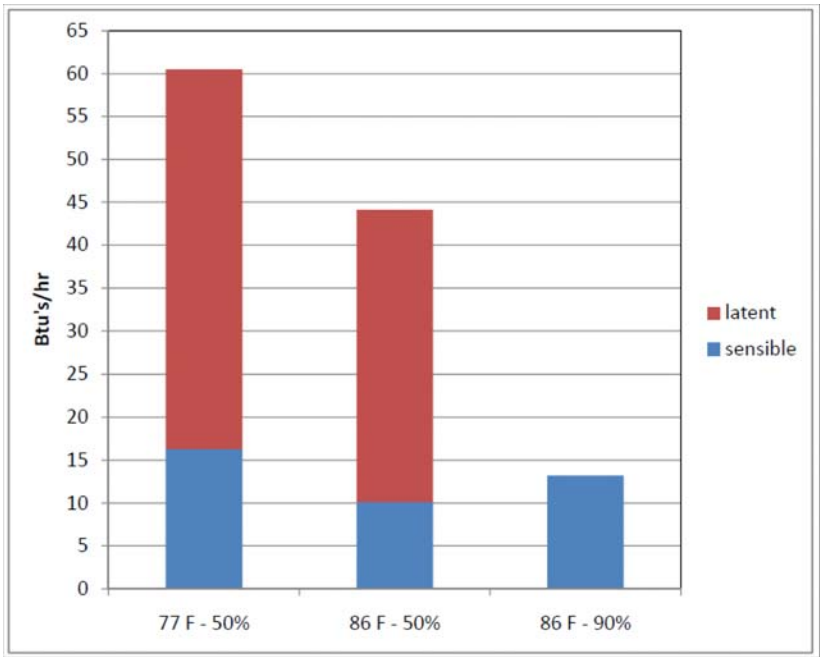

Figure 3. Heat loss from a five-pound-broiler.

Here is the problem growers face. During hot weather we use evaporative cooling to lower our house temperatures to increase the transfer of heat from the birds to the air (sensible heat loss). The downside is that this cooling comes at a cost, increased humidity. For every 1°F of cooling produced through the evaporation of water the relative humidity of the air in a house will increase approximately 2.5%. Though the air temperature is lower, the increase in the relative humidity reduces the bird's ability to cool itself through the evaporation of water off of its own respiratory system. So though we are decreasing house air temperature using evaporative cooling, we are adversely affecting the bird's primary method of cooling itself because we are increasing humidity.

For example, let's say the house temperature is 86°F and the relative humidity is 50%. Based on the research conducted by Genc and Portier the total heat loss from a five-pound-bird would be approximately 45 Btu's/hr. We turn on our evaporative cooling system and decrease the house temperature to 77°F which will in turn increases the relative humidity to approximately 75%. Though the air temperature is nearly ten degrees lower, the fact is that total heat loss from the bird would only be increased by approximately one Btu/hr. Considering the fact that a five-pound-bird needs to lose approximately 60 Btu's/hr, it is hard to see how utilizing an evaporative cooling system would significantly improve bird performance under these conditions. Interestingly enough, in the typical poultry house utilizing evaporative cooling, house temperatures during hot and humid weather are often even more stressful with house temperatures in the low to mid eighties and relative humidity over 80% (Figure 4). According to the research conducted by Genc and Porter, as well as others, this should result in an increased level of heat stress, but we know from experience that it typically doesn't. Why? The answer is simply **air speed**.

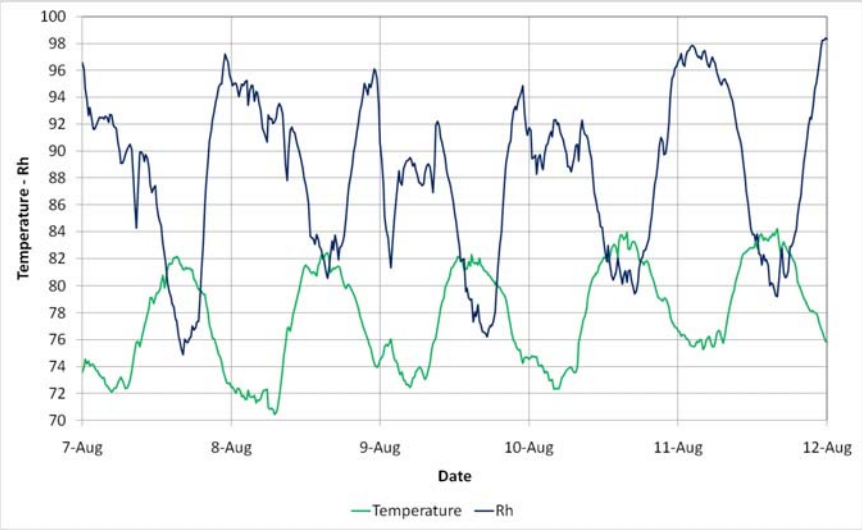

Figure 4. Inside conditions in a poultry house using evaporative cooling pads during hot-humid weather.

Air speed increases the amount of heat loss to the air around a bird thus reducing the need for a bird to rely on evaporation of moisture from its respiratory system to cool itself. The higher the air speed the greater the amount of heat a bird will lose to the air and the lower the amount of heat the bird needs to lose through panting, thus reducing the importance of relative humidity.

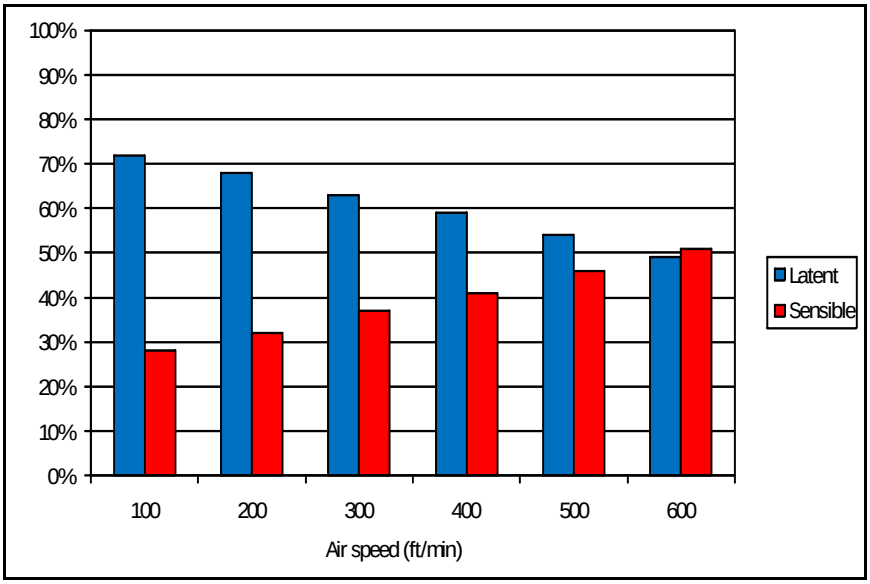

Figure 5. Heat loss percentages from broiler at 85°F at various air speeds.

Figure 5 illustrates the percentage breakdown of heat loss from a five-pound-bird at 85°F (52 % Rh) as a function of air speed (Simmons et al, 1997). At an air velocity of 100 ft/min, approximately 72% of a bird's heat loss is due to the evaporation of water off of its respiratory system and therefore it would be adversely affected by a high relative humidity. Conversely, at an air speed of 600 ft/min, the heat loss due to respiratory moisture evaporation decreases to less than 50%, significantly reducing the importance of the relative humidity of the air when it comes to bird cooling. It all comes down to a couple of simple facts; without air movement evaporative cooling is potentially dangerous and as air velocity increases, the importance of relative humidity to a bird decreases.

Too many times poultry producers view evaporative cooling as if it is "air conditioning". It is not. Air conditioning decreases air temperature and **removes** moisture from a house. Evaporative cooling decreases air temperature and **adds** moisture to the house, a significant difference. In some areas of the world the addition of moisture to the air is welcomed. For instance, in

desert areas many people use “swamp coolers” (a small box with evaporative pads and a blower) to cool their dwelling houses instead of air conditioning. If it is 105°F with a relative humidity of 10%, a residential swamp cooler unit could be used to drop the temperature inside a house to 76°F and increase the relative humidity to a little over 50%. A homeowner would get both cooling as well as needed humidity at a very low cost. But, if a homeowner in a humid climate used the same type of cooling system on a typical summer day (95°F, 55% Rh), they would end up with far from ideal living conditions (83°F, 85% Rh). We are basically using a cooling system in our poultry houses which is best suited for use in a hot, dry climate not in hot, humid climates. The only reason we can use it effectively is because of the high air speeds and air exchange rates that exist in our poultry houses.

The point is that evaporative cooling is a very good method of cooling birds only when used in conjunction with air moving over the birds. Birds can become heat stressed at surprisingly low temperatures (mid to low seventies) when the humidity is high and air speeds are low. Yes, the house may seem “cool” to you, but keep in mind that a bird is much more sensitive to high humidity conditions than you are. Make sure before using evaporative cooling systems that you have adequate fans running to offset the detrimental effects of the increased humidity caused by the evaporative cooling pads. For older birds this often requires operating all tunnel fans in a house before using the evaporative cooling system. Not only do we need to offset the negative effects of the high humidity caused by the evaporative cooling, but older birds are well feathered and space between them tends to be limited thus requiring a high air speed to remove heat from their bodies.

With younger birds fewer fans can be used because pad systems are typically only being used to “temper” the incoming air which results in a lower incoming relative humidity. For instance, if we had a house with two-week-old birds when outside temperature was 100°F with a relative humidity 30%, we could add water to a pad system sparingly which would decrease the incoming air temperature to 90°F and the relative humidity would increase to approximately 55%. A small number of fans could be used to keep the birds comfortable not only because the relative humidity is fairly low but because the young birds are not producing much heat, they are not completely feathered, and there is a large amount of space between birds thus requiring relatively lower air speeds to pull heat from their bodies.

Would we be better off without evaporative cooling systems in our houses? Definitely not. We need an inexpensive method of reducing house temperatures during hot weather. Though air speed is a very effective method of removing heat from a bird, the smaller the difference in temperature between the air and the bird’s body the less heat removed from a bird. If the temperature of the air moving over a bird is equal to its body temperature essentially no heat will be lost to the air. It is not an either/or situation. A producer needs to utilize both air movement and evaporative cooling during hot weather to keep birds comfortable and productive. But, always keep in mind that in order to maximize bird cooling it is air movement first, evaporative cooling second.

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